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AN ASSESSMENT OF GENERAL AVIATION UTILIZATION
OF ADVANCED AVIONICS TECHNOLOGY

Gilbert F. Quinby

G. F. QUINBY ASSOCIATES
Ft. Washington, Pennsylvania 19034

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Langley Research Center
Hampton, Virginia 23665



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PART I - ABSTRACT

At the request of NASA Langley Research Center, the author undertook an assessment of General Aviation's utilization of Advanced Avionics Technology. Needs of the General Aviation Industry for services and facilities which might be supplied by NASA were examined. In the data collection phase, twenty-one individuals from nine manufacturing companies in General Aviation were interviewed against a carefully prepared meeting format. All respondents were candid and dealt openly with matters of proprietary sensitivity. Their competitive interests have been protected in the process of synthesizing the information in report form.

The resulting report is presented as objectively as possible in a conscientious effort to communicate the opinions and convictions of the key technical managers of industry who were interviewed. The report credits General Aviation Avionics Manufacturers with a high degree of technology transfer from the forcing industries such as television, automotive, and computers and a demonstrated ability to apply advanced technology such as large scale integration and microprocessors to avionics functions in an innovative and cost effective manner. Constraints on advanced technology caused by necessary safety regulation were occasionally deplored but accepted. The industry's traditional resistance to any unnecessary regimentation or standardization was confirmed. Industry's self-sufficiency in applying advanced technology to avionics product development was amply demonstrated. NASA support was perceived by the industry to be unnecessary in major areas such as system architecture, microprocessor application, and multi-modal use of cathode ray tubes. NASA research capability could be supportive in areas of basic mechanics of turbulence in weather and alternative means for its sensing. Other areas that should be explored for NASA research assistance are improvements in aircraft antenna pattern management at L-Band and C-Band, and possibly a General Aviation cockpit human factors study using NTSB and Aviation Safety Reporting System data to compare the functional reliability of various types of avionics controls.

PART II - BACKGROUND

Technology transfer between NASA and its predecessor agency and the General Aviation Industry has a long and productive history. The present study will concern itself with the phase which started with a NASA-sponsored symposium at Stanford University in 1975. Among the many accomplishments of that symposium was a recommendation adopted by industry representatives that NASA resources be used to explore some aspects of advanced digital avionics systems for eventual application to General Aviation aircraft. Particular emphasis was to be placed on system architecture alternatives as distinct from simple hardware development. The record of the 1975 Stanford Symposium exists as NASA CR-137861 "Workshop on General Aviation Advanced Avionics Systems" and makes worthwhile reading for anyone interested in more depth of historical background.

The Advanced Avionics Systems Study was launched at Ames Research Center with Dr. Dallas Dennery as Program Manager under the direction of Brent Creer in the Aircraft Guidance and Navigation Branch. A modest staff did initial exploratory work on the program at Ames during 1976, taking the task far enough to define the objective of a request for technical proposal which was sent out to interested Avionics Manufacturers in 1977. Also in 1977, Dr. Dennery presented a concise paper on the program to SAE's Business Aircraft Meeting in Wichita, Kansas. This paper, SAE No. 970569 was not enthusiastically received by the General Aviation community, and to some it made NASA appear more of a competitor than contributor to General Aviation avionics development.

Technical proposals were received at NASA-Ames from a satisfactory number of Avionics Manufacturers both in and out of the General Aviation field. A contract to develop and demonstrate an advanced General Aviation Avionics System was let to Minneapolis Honeywell with King Radio as a sub-contractor. By early 1980, the Demonstration Advanced Avionics System (DAAS) was flyable in simulator form at Minneapolis and in late March the author was one of a relatively small number of General Aviation people to have actual hands-on time on the DAAS simulator.

The DAAS hardware; CRT displays, modified off-the-shelf panel-mounted King Radio components, and input devices all

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linked into a system with microprocessors and limited redundancy will be installed in a Cessna 400-series aircraft as a part of the King Radio sub-contract and will be available for flight demonstration.

Meanwhile in the laboratories of the General Aviation Avionics Manufacturers throughout the United States, digital avionics technology was advancing at a remarkably rapid pace. The capacity and speed of large scale integrated circuits were in the process of rapidly obsoleting the first generation of digital avionics. Driven mostly by demand pressures outside aviation, these LSI devices, particularly microprocessors, are being applied to avionics hardware and systems at a rate which some feel will obsolete the Ames-Honeywell-King DAAS before it can be installed and flown. The Boeing 767 and 757 aircraft are having their flight decks designed around extensive use of cathode ray tube displays of flight data including electronic horizontal situation indicators and electronic attitude displays. It can be safely conjectured that the large General Aviation market will be an early competitive target for adapted versions of the Boeing innovation.

Three or four avionics manufacturers are solidly in the General Aviation marketplace with multi-modal displays on the digital weather radar cathode ray tube. One consequence of this application of rapidly advancing technology is a certification problem which is getting accelerated attention from the Radio Technical Commission for Aeronautics (RTCA). Essentially all weather radars including the newest digitally displayed models carry FAA TSO C-63b which is based on RTCA Document DO-134, the product of Committee ICG-3 published in 1967. Until this document is amended and updated to include standards for multi-modal use of the weather radar display, TSO C-63 cannot apply to any part of the installation other than the weather radar itself. So RTCA Special Committee 133 is well along in developing the standards for the other modes supplementing the weather radar display on the digital CRT. In this process its efforts are directed to other than primary flight instrument modes, so the intention of SC-133 is to provide for certification of alpha numeric page data display for check lists and other procedural information, and graphic display such as Area Navigation waypoints and routes superimposed on the weather display or displayed separately.

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The preparation of standards for primary flight instrumentation has historically come under the purview of SAE and a triad sub-committee is presently preparing minimum performance standards for airborne multi-function electronics displays, AS-8034. This standard will not deal with weather radar displays, but will cover applications such as primary flight and navigation, systems and warning, and control displays. The second draft of this proposed standard was reviewed by the sub-committee on July 16 and 17, 1980. FAA is an active member of the sub-committee and is represented by technically qualified people from the FAA Technical Center at Atlantic City. Qualified General Aviation representation is participating in the preparation of this aeronautical standard for electronic displays.

The standards and certification processes applicable to Air Transport installations are not directly applicable to General Aviation installations. Among the differences between the two marketplaces, two are significant:

1. Longevity.

A generation of avionics for use in heavy air transport aircraft is expected to survive without major technical modification for the ten or fifteen year useful life of the aircraft in which it was originally installed on the production line. While there are historical exceptions to this philosophy, it is nevertheless a basic objective of the Airline operator to avoid the expense and downtime of his aircraft for the purpose of major avionics upgrading.

The General Aviation aircraft, on the other hand, frequently wears three or more suits of avionics during its life as its ownership and mission change and as new technology offers more reliable, higher performance avionics. This generates a retrofit, or aftermarket for field installation of General Aviation avionics at least as large as the new aircraft production line installation market.

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2. Life Cycle Cost.

Air Transport aircraft utilization is an order of magnitude higher than that typical of business aircraft in the General Aviation Fleet. This means that annual utilization can be two or more times the calculated mean-time-between-failure (MTBF) for the avionics installed. So maintenance costs are more important to the carrier than initial cost. This makes for a very different type of design than would be appropriate for avionics installed in the General Aviation Fleet, where initial cost is more significant than an increment of reliability which might call for maintenance only every three years or more.

While the primary concern of the present study is advanced technology and its transfer and utilization, certification is one of the subordinate concerns which continued to recur. There did not appear to be room for a direct NASA contribution to this vaguely unsatisfactory process, but it might be a subject justifying further study.

In this report, the term "avionics" is intended to include all of the electronic hardware aboard the aircraft and particularly that which is involved with the reception, transmission, processing, display and use of information arriving or departing at radio frequencies. NASA's usage "avionics, controls and human factors" is included in the term avionics as used in this report. For precise definition the "controls" aspect excludes automatic flight control devices and is limited to the controls by which the performance of the avionics is managed. No particular attempt was made to force a definition of "human factors" on those interviewed and the reader may well infer that this term means different things to different people.

PART III - METHOD

Prior to finalization of the Statement of Work on which this study is based, telephone interviews were conducted with a number of top management officials in General Aviation aircraft and avionics concerns. These preliminary discussions gave the author confidence that those concerns

would cooperate fully in the study. In the process of actually scheduling the interviews and during the data collection phase of the study, one company - the Collins General Aviation Division of Rockwell International - had second thoughts and declined to participate. Two other companies not included on the Statement of Work, King Radio and NARCO Avionics, agreed to participate.

The list of General Aviation manufacturers participating in the data gathering part of this study is not intended to be complete, but rather representative of both Airframe and Avionics Manufacturers. The sample size and geographic location of individual companies was selected more to fit the constraints of time and travel than to structure the sample in any particular way.

As the substance of the study took better definition from preliminary conversations the meeting outline was drafted and reviewed with personnel at Langley Research Center. It appears in refined form as Appendix 2. Each company interviewed was asked each of the questions on the meeting format in order to be consistent in the development of consensus. Each discussion departed extensively from the meeting format as outlined and some of the important value of the data collected is in these gratuitous departures from the structured format.

The initial interview was held with RCA in Van Nuys on June 24, and the final interview was with King Radio in Olathe, Kansas on August 5. A list of the company personnel participating in each interview is attached as Appendix 3.

The process of drafting the final report presented an interesting number of alternative ways to organize the data collected in interviews. The temptation was strong to develop a matrix format and several attempts were drafted. Due to the depth of knowledge and opinion offered by the interviewees, a matrix proved to be nothing but a collection of footnotes and embellishments. The matrix idea was abandoned primarily because it risks over-simplification of complex answers to complex questions. The format adopted in Part IV below for this draft appears to have a much better potential for communication of the subjects covered.

PART IV - RESULTS OF MEETINGS

This part of the report presents a consensus of comments of key industry figures in the form of a synthesis of meeting discussions grouped under topics as identified in the meeting format. Topics and issues are presented in the order followed in the meetings; proceeding from the introductory material through a definition of the company's historic awareness of NASA's resources, followed by a philosophical discussion of General Aviation's self-sufficiency in applying advanced avionics technology to its needs. On this established base, specific technical areas were discussed to explore General Aviation avionics technology needs and NASA capabilities. Finally, the discussants general industry views were narrowed down to specific questions of his company's situation in the application of certain advanced avionics technologies. Throughout these discussions, gratuitous observations were offered and noted. They are grouped after the more formal discussion reports.

The initial background question was regarding the specific company's awareness of and use of NASA's resources in avionics. Most companies responded that they were reasonably well coupled to NASA either directly or through an affiliated or parent organization. Airframe Manufacturers questioned expressed high regard for the aerodynamic and propulsion activities of NASA with which they were in close touch. Avionics Manufacturers either had no avionics liaison with NASA or a very specialized awareness such as having bid on the Ames Demonstration Advanced Avionics Systems Program. Even those Avionics Manufacturers who tried to maintain close liaison with NASA avionics activities found that this effort resulted in too tight a communication; such as between a Project Engineer at a manufacturer and a Program Manager at a center.

Several respondents answered the question with a second fairly provocative question; what is NASA's awareness of General Aviation avionics capabilities and needs? In at least two companies it developed that the author was the first NASA "Representative" to visit and examine their facility. There was a general consensus that NASA needed to learn more about General Aviation's avionics capabilities and requirements, and should somehow make General Aviation more aware through publication or symposium of NASA's applicable resources.

A number of the individuals interviewed were familiar with the proposed NASA Avionics and Controls Program for General Aviation transmitted by Mr. Robert Tapscott of Langley Research Center in December of 1979. To some degree the res-

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pondents to the present study who had participated in a response to Tapscott's request for comments felt that this was either a duplication of some of the effort, or evidence that NASA had not found their earlier responses sufficiently credible. Any concern expressed in this regard was dealt with by using the present study as evidence that NASA Langley Research Center was vitally interested in getting a more amplified response from key industry figures than had been possible with the correspondence exchanged earlier in the year. While some disagreement may appear superficially, between the industry's responses to the Tapscott inquiry and the present consensus study, it must be remembered that the two methodologies are quite different, and the present study permitted discussion to proceed well beyond the specific proposals in the NASA Avionics and Control Program document.

In summary, while General Aviation admitted a need to learn more about NASA's resources and facilities appropriate to General Aviation, there was a consistent strong expression that communication between NASA and the industry could be enhanced if NASA knew more of the industry's strengths and requirements. The hope was expressed that the present study could effect improvement in these areas.

General Aviation's Self-Sufficiency in Advanced Avionics Technology Policies

As a prelude to a discussion of specific technology areas, two areas of avionics technology transfer policy or philosophy were reviewed. These areas were technology forecasting and risk taking. The review served two purposes; it challenged industry's sense of self-sufficiency in these basic policy areas, and it prepared the discussants for productive responses to the more specific questions to follow.

The extent of the technology forecast available to the General Aviation Avionics Manufacturer is in direct proportion to the size of the company or corporate organization involved. A large company with a central corporate research function will undertake technology forecasting out as far as five years even in the present dynamic times. A small company will be more reactive to inputs from vendors and competitors and tend to limit its technology forecast cycle to the product development cycle which is typically two to three years. Consistent concern was expressed that the rapid advancement of digital avionics technology was reducing the profitable life of a new product in the marketplace. If digital technology obsolesces itself every two to four years, the industry may have seen the last of the successful products which survive from five to ten years in the highly competitive marketplace. This trend will have an economic

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effect either to increase product prices to recover fixed charges in the shorter life cycle, or to reduce development costs in order to offer more attractive prices. What contribution could NASA make to this challenging aspect of advancing technology? In the perception of the respondents, essentially none. It was felt that this was a marketplace-driven phenomenon characterized by cost and pricing trade-offs. It is the general consensus of the industry that NASA is not facile in the area of costs and pricing.

Risk-taking or risk-management is a policy aspect of Avionics Research and Development Programs closely related to the accuracy of a technology forecast in a rapidly developing technology. Here again Avionics companies which are members of large corporate families enjoy a certain amount of basic research capability in their corporate research and development organization. Interestingly enough this resource is regarded as a mixed blessing by the operating people in the avionics manufacturing profit centers. Here emerged the first development of the theme that General Aviation does not have sufficient market size to justify creative technology for itself. The risk-taking in applying "new" technology to General Aviation avionics needs is nothing but selective technology transfer from other industries with sufficient volume to justify the expenditures that it takes to reduce advanced concepts to productive practice. The catalysts in this process appear to be the vendors who develop advanced technology components and functions for the driving industries such as automotive, entertainment, computer and others and then immediately turn to new and smaller markets in the hope of incremental sales and profits.

At least one area of research risk was described by respondents as likely to justify public resource investment. Hazardous weather phenomena are poorly understood and industry is poorly configured to do the fundamental research necessary for improved understanding. Detection and definition of turbulence by airborne sensors is indirect and imperfect. Research into the fundamental nature of the turbulence generating phenomena, the development of effective direct sensors of turbulence, and the correlation of products of indirect sensors such as those for precipitation or lightning, appears to be an area where public funding and high risk research would be justified.

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It should be noted here that the General Aviation customer is probably more reluctant to change his operating practice than the customer for an automobile or a television game or a computer system. This reluctance is compounded of a discipline for safety and a strict regulatory environment. Whether it is justified or not, it tends to stretch out product life and moderate the natural tendency towards rapid product technology turnover. This inherent resistance to change tends to penalize the manufacturer who takes risks with the first generation of a new avionics function and reward the manufacturer who learns from the mistakes of the pioneer and designs the second sub-generation of a new function into a marketplace where the pioneer has softened the resistance to change.

Here again industry finds no way in which NASA could constructively participate in product design risk-taking.

There was a third area of industry policy which came up in discussion with three or four participants. Some discussants found General Aviation avionics deficient in component reliability and consequent maintenance support. One manufacturer characterized this as the number one problem in General Aviation today, and not getting any better. Some Airframe Manufacturers feel that the maintenance of double or triple sources for avionics components is adequate assurance that product reliability of at least an industry norm will be maintained. But most agree that reaction time to detect and correct an unreliable design is too long, and too expensive in good will and down time. Here again none of the respondents could suggest a credible role for NASA in the correction of this difficulty.

Assessment of Specific Technical Areas of NASA Capability System Architecture

Avionics Manufacturers are readying a new generation of advanced digital avionics aimed at the sophisticated end of the General Aviation Fleet. NASA can take some credit for initializing this process, not with the Demonstration Advanced Avionics System out of Ames but with the Terminally Configured Vehicle (TCV) at Langley. It is a permissible over-simplification to observe that Boeing drew heavily on some of the TCV avionics

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so as to develop a request for proposal from interested Avionics Manufacturers for avionics functions in the Boeing 767 and 757 airplanes. Bidders who responded to these requests, both successfully and unsuccessfully, are predictably turning to the General Aviation market.

A standardized system architecture is not a concern in industry at this point. Various manufacturers will develop their own product and interfaces and in all probability the first generation system architecture will just grow like Topsy. Any detriment caused by this disorder is more than offset by the opportunity to innovate in an atmosphere free of the constraints of standards. There was a unanimous resistance to standardization of system architecture for General Aviation digital avionics certainly for the present and indefinitely unless clearly necessary.

Apart from the questions of standards, a need for guidelines or leadership in system architecture was strongly expressed by only one of the responding companies.

Sensor Development

For purpose of starting this discussion it was observed that General Aviation had some sensors which were less than perfectly accurate and stable, and NASA had claimed some success in the development of simplified, low-cost, improved sensing devices. The respondents were split almost evenly in their reaction to this opportunity. Those expressing a negative reaction repeated the theme that NASA does not know how to design to cost. There were pragmatic expressions of the fact that General Aviation gets the sensor performance it is capable of paying for. Fuel gauges were used as an example. On small General Aviation airplanes nobody trusts the fuel gauges. On large airplanes with large operating budgets, expensive fuel flow sensors and displays are alleged to be a great improvement and there appears to be adequate market and competitive effort to improve their technology and cost effectiveness. Still it was recognized that there will be an increased need for sensor accuracy and probably variety; the positive portion of the respondents did not feel at all comfortable dismissing this possible NASA area of assistance out of hand. So this area of study may have some promise and justifies further definition of industry needs and NASA capabilities.

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Incidentally, it is about here in the discussion that the question of propriety and proprietary rights begins to emerge. The means by which NASA would catalyze the development of, say, a directional sensor potentially simpler, more accurate, more stable and less expensive than those presently in use would have to be reviewed very carefully. Should public funds be used, for instance, to put a new competitor in that business? Or should all this information be developed at a NASA Center in a suitable goldfish bowl with large neon signs such that any industry entity was free to pick up a NASA beginning at any point and run with it? It must also be remembered that sensors developed by manufacturers to the trade are developed under constraints of safety regulation, which would not apply at least to the initial development of a sensor by a NASA Center. The direct and indirect costs of certification for an innovative replacement for an established certified sensor might be substantial.

Antenna Technology Advances

This is the area in which industry spokesmen were most supportive of NASA assistance. Perhaps this was because the author was impressed with the RF anechoic measuring capability at Langley Research Center. Perhaps it was because the industry recognizes that its past "seat-of-the-pants" airborne antenna pattern measurement repetitiveness was not adequate for future systems such as B-CAS and GPS. Regardless of the reason it would be very difficult for any industry element to capitalize on antenna pattern measurement capability like that at the Langley Research Center.

One respondent wished he could try an airborne radar antenna array electronically steerable in elevation. One wanted to try simulating two aircraft in closing circular banked courses on a B-CAS situation. All recognized that the capability which existed in NASA could be to the advantage of General Aviation as it moved into new more demanding avionics systems. But none were confident of a fair way to take advantage of these facilities. The variability would probably be the primary problem here; the production duplication of an antenna pattern on an airplane depends on the bonding of the skin sheets which is very difficult to control. In the retrofit market, field installation of antennas has little or no pattern measuring guidance.

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It is recognized in General Aviation that antenna installation and pattern measurement methods are inadequate for demands which will be placed on them by the system in coming years. Langley Research Center has antenna pattern measuring capability which could alleviate some of industry's deficiency. Could a mechanism be developed to put the Langley antenna pattern measuring facility at the disposal of industry at a reasonable cost without compromising a proprietary asset? Could the Langley Research Facility investigate antenna pattern anomalies and measuring techniques so as to improve the uniformity and repeatability of production line and field installed antennas? There was general agreement that these questions justified further study. And Airframe Manufacturers need more information than they are getting regarding the aerodynamic and electronic deficiencies of flush or low drag antennas.

Display Technology

General Aviation Weather Radar Manufacturers have already adapted their digital cathode ray tube displays to multi-modal operation, and are in the planning stage for electronic flight instrumentation. Some Avionics Manufacturers estimated EFI product availability as early as 1982 or 1983. While all digital cathode ray tubes in service today are the standard raster developed for the television market, optional products offering the Japanese high resolution CRT may be expected. It is interesting to note that General Aviation principals, normally a nationalistic bunch, are not particularly upset by the failure of U.S. CRT manufacturers to invest the fairly high fixed cost of developing our own high resolution CRT. If the customers really want high resolution, U.S. radar manufacturers will buy the Japanese tube. Incidentally, no one seems to fault NASA for failing to assure U.S. technical supremacy in this instance.

Flat plate electronic display alternatives to the CRT are subject to intense development pressure for other applications, and General Aviation is watching such developments as the three color liquid crystal display and an experimental LED matrix featuring 4,000 diodes per square inch. But as of this time none of the manufacturers feel that any alternatives to the color cathode ray tube are worth incorporating in product planning.

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Advance developments in display application taking advantage of increased memory and speed capability of digital components will include provision for approach plate displays and up-linked ground sensed weather displays. Low mean-time-between-failure (MTBF) of mechanical gyros appears to be a strong forcing factor to the development of electronic attitude instrumentation, and the development of the lazer gyro is being watched closely.

One Airframe Manufacturer respondent expressed a need for more work in the alert/alarm human factors area. He himself was not aware of any applicable accomplishments in this area from the program at Ames Research Center. This may be because George Cooper's excellent work on this subject ("A Survey of the Status of and Philosophies Relating to Cockpit Warning Systems", NASA CR-152071 of June, 1977) was oriented to Air Carrier turbojet aircraft.

Here again as in the specifics of system architecture and simplified sensors the industry recognized that General Aviation as a market doesn't have enough driving force to develop specific technology for its purposes, but does adapt itself to enjoy the benefits of technologies developed for industries with large volume markets. And with the technology transfer catalyzed by component vendors it is difficult to see a role for NASA. One manufacturer suggested that NASA might be of some service in counseling such human factors as symbology, but had second thoughts when this appeared to smack of standardization.

Finally in display technology it was noted that progress continued to be made towards headup display with safety as a strong driving force.

Avionics Controls and Human Factors

At least 50% of the respondents felt that NASA could make a badly needed and positive contribution to improved avionics controls. Some were familiar with the work being done by Dr. Dennerly's crew at Ames Research Center and felt that there was long range applicability for some of this technology in General Aviation. Only the most independent diehards felt that the proliferation of knobs and keyboard schemes by which we control our avionics is a healthy thing and most recognized that there is a serious safety deficiency possible here.

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One respondent felt that the most logical source for control of avionics including frequency changes was the ground computer complex through an up-link such as DABS. In assessing the simplicity and reliability of new concepts of control, respondents were suspicious of the work of human factors specialists and emphasized the need for operational evaluation of innovation. The discussion frequently encountered difficulties with defining exactly what human factors were, and usually rationalized them to be whatever made the end user most comfortable and confident in control manipulation. And since the end user is almost always a highly competent pilot in his own eyes, it makes very little difference that a keyboard configuration is as it is because some PhD in Human Factors made it that way.

As in other specific technologies, industry was not confident that we had good means available to us to take advantage of NASA assistance in avionics control human factors. With experiments going on in voice commands, keyboard configuration reliability, tactile versus audible feedback for pushbuttons, incrementing versus absolute tuning and a host of other variations and combinations perhaps NASA could perform a role of critical analysis and avoid adding to an already overly proliferated situation. Some respondents recognized the area of the human factors of avionics controls as the greatest possible potential safety breakthrough available from General Aviation technology. Just as there has been some cockpit improvement as a fallout from GAMA's Pilot's Operating Handbook efforts, perhaps NASA could do a human factors analysis of General Aviation Accident Reports in NTSB or in the data base of the Aviation Safety Reporting System at Battelle Columbus Labs.

Other Specific Technologies

The following were not necessarily discussed with all of the respondent companies, but nevertheless justify inclusion for the sake of completeness.

Fibre Optics

Vendors are pushing highly developed material, terminals appear to be available, and at least one Airframe Manufacturer has experimented. Industry is confident that it is capable of applying this technology where and when the benefits justify the cost. Freedom from coupled inter-system interference is a driving force.

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Fluidics

Ho-hum. General comment; an answer in search of a question. Only one respondent expressed a gut feel that there was potential in this field of technology.

NAVSTAR Global Positioning System

Several respondents felt that NASA could contribute as a reasonably objective technical consultant to industry in the utilization of satellite-based navigation or other satellite-based systems. While nobody really expects VOR/DME navigation to live forever as an exclusive International Standard, there is a feeling, perhaps engendered by FAA's attitude, that aviation is being pressured prematurely into the use of this particular satellite system.

CAS/CDTI

General Aviation seems to have a rather helpless feeling in the face of the understandably strong push by the Airlines, the Congress and the FAA for a collision avoidance system. Could NASA serve the role of consultant here as well as in GPS? Both are politically sensitive.

DABS Data Link Utilization

We know we're going to get DABS, and we know it has a fairly extensive data link capacity. We are not sure how to make best use of this resource, and we are not sure that FAA does either. Would NASA participation in this program be an asset or a liability?

Microwave Landing System

Is there any way NASA could assist the industry in getting MLS operational? Can the MLS transmitter at NASA Wallops Island be made available for avionics test?

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Voice Communication Intelligibility

This is alleged by Controllers to be a serious system safety problem. It's a combination of transducer inferiority and aging, microphone technique, communication discipline and probably a lot more. Respondents feel nobody is paying attention to this problem area.

Software Control

There is a feeling of concern in the industry over the question of modifiability of microprocessor programs. Avionics Manufacturers who program microprocessors on their products cannot be held responsible for certification or performance if that program is changed by the Aircraft Manufacturer or operator to fit new requirements, yet Airlines feel a need to have this capability. Translation of the heavy jet transport version of this concern into the General Aviation Aftermarket environment will offer exciting challenges.

PART V - STATUS OF ADVANCED TECHNOLOGY UTILIZATION BY
RESPONDENTS

Of the nine manufacturers interviewed, eight were involved to some degree in the development and manufacture of avionics. All of these eight are in some stage of utilization of microprocessors, the pioneers have had microprocessors in products for years, while those with less extensive research and development activities are well along in product design for introduction later in 1980 or early in 1981.

Of the eight Avionics Manufacturers, four or five are engaged in the manufacture of products incorporating cathode ray tubes and three or four of these have developed digital video processing for multi-modal use of the CRT display.

A majority of the respondents either directly or indirectly in avionics manufacture are also in the manufacture of flight control systems. The technology applied to the design and performance evaluation of flight control system components ranges all the way from super-sophisticated modeling and simulator utilization to super subjective "fly-it, and if it feels okay to the boss, build it". Those manufacturers at the unsophisticated end of the flight control design spectrum agreed that there might be some potential benefit if NASA could find a way to sell them time on some appropriate NASA simulator. But essentially all respondents were pragmatic about the availability of better ways to subsidize General Aviation. Tax breaks for R & D expenditures was given as an example of a more efficient "subsidy" by at least two respondents.

PART VI - GRATUITOUS OBSERVATIONS

Communication between NASA and General Aviation, particularly in areas of avionics, continues to be deficient as perceived by the industry. While admitting that General Aviation should make more of an effort to learn what NASA is doing, many respondents felt that NASA should get out of its centers and into industry's laboratories and factories to become better aware of the capabilities and deficiencies of the industry. This applies not only to the Avionics Manufacturer and Aircraft Manufacturer, but to the various types of operator of equipped airplanes in the variety of services that constitute General Aviation. And it was expressed frequently that once acquired, this familiarity in a technology as dynamic as the application of avionics to General Aviation would need to be renewed and maintained.

One suggestion was that a specialized periodic publication of NASA's facilities and accomplishments appropriate to General Aviation avionics be undertaken, with reader feedback encouraged and carefully analyzed for response. MIT has a publication entitled, "Reports on Research" offered through its Industrial Liaison Office which was used as an example of effective periodical communication.

While NASA's Aeronautics Advisory Committee was recognized and respected for its work in propulsion, aerodynamics, structures, materials and so forth, it does not get high marks in the field of avionics. Also there is the feeling that even in the aerodynamics and propulsion subjects, the older Research and Technology Advisory Committees were more effective means for the industry to communicate to NASA's management than is apparently being accomplished with the Aeronautics Advisory Committee.

Two or three companies, active in AAC suggested that General Aviation avionics was a subject of sufficient importance to supplement the AAC Sub-Committee activity with a symposium, perhaps annually, and perhaps jointly sponsored by NASA and FAA. Another comment suggested that NASA should concentrate more on publishing reports of the actual progress and accomplishments of the Centers in avionics activities and perhaps publish less documents related to new program justification.

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In the matter of conferences and meetings, it was noted that when all of the competitors in a fiercely competitive marketplace gather together under any sponsorship, the discussion will be somewhat reserved and proprietary interests will be well protected. The candor with which the author was greeted by these competitors shows that this can be overcome in a one-on-one situation. So NASA should encourage visits by commercial entities for discussion of work at the NASA Centers and NASA should also find a means by which appropriate NASA personnel can establish direct or indirect continuously updated knowledge of what is going on in the General Aviation Avionics Industry.

PART VII - RECOMMENDATIONS

As was emphasized in the Abstract in Part I of this report, the author has made every effort to keep his subjective judgment from coloring the data gathering and reporting responsibility of this task. The recommendations listed below are those which were deemed most important to the key industry figures who were interviewed by the author. To draw the typical conclusions at the close of the presentation of the data in Part IV and VI above is an unnecessary editorial license in the present case. Therefore, the following recommendations are presented without any particular evaluation or establishment of priority by the author. Also the reader will note that Parts IV and VI above are liberally sprinkled with implied recommendations or provocative questions bordering on recommendations, and the following reiterates but presents no new material.

1. All aviation needs a better understanding of severe turbulence and improved methods to sense and anticipate this phenomenon. It is recommended that NASA explore its own mission in search for a means by which the efforts of other agencies could be supplemented. As a minimum a service could be performed by collecting the missions and products of other Federal Agencies active in the field of thunderstorm and other turbulence detection.
2. Planned and proposed new systems such as those for collision avoidance, microwave landing, and satellite based navigation will either impose new and more exacting demands on General Aviation aircraft antenna pattern uniformity, or suffer system degradation because of lack thereof. Both General Aviation as a system user and FAA as system manager appear to need more knowledge of airborne antenna pattern characteristics and their management. NASA has facilities and resources that might be beneficially applied to such research.
3. While General Aviation has resisted the ARINC type of approach to cockpit standardization and will continue to resist it, some responsible managers would welcome guidance in the form of a safety assessment of the various avionics control alternatives. A human factors analysis

PART VII

of avionics controls correlated with NTSB Accident Reports and NASA's Aviation Safety Reporting System data base at Battelle Laboratories might provide helpful design guidance for avionics controls of maximum functional reliability and minimal error potential.

4. NASA should find improved means to communicate its capabilities, facilities, and accomplishments related to General Aviation avionics controls and human factors. This communication could be in the form of a periodical publication similar to the facilities brochure common in industry, or perhaps one or more technical symposiums on areas of advanced technology where NASA has accomplishments to ventilate and industry has a need for cross fertilization.
5. Either through the medium of the Aeronautics Advisory Committee, or independent thereof, encourage visits of appropriate industry technical personnel to NASA facilities and arrange for NASA personnel to become more familiar with industry research capabilities, operating requirements, and technical deficiencies.

APPENDIX 1

Date _____

See Addressees Attached List

Dear _____:

I have been retained by NASA's Langley Research Center to do a technology assessment on General Aviation avionics displays, controls and human factors. I agreed to consult with key individuals in an effort to determine the response of critical companies in areas such as the following:

1. What is the state of application of advanced technology to General Aviation displays, avionics, and controls within your company?
2. What is your company's need for further advanced concept technology and facility support such as that which exists in NASA's General Aviation Program?
3. What is your company's awareness of and reaction to on-going NASA programs in displays, avionics and controls for General Aviation?

I propose to arrange a visit with you and people in your organization interested in these matters sometime during the coming thirty days. By the time you receive this confirming letter a convenient date for our discussion may have been discussed by phone.

There will be two products of my effort under this contract. First, I will deliver to NASA an accurate report of the specific and collective industry attitudes with regard to the three question areas listed above. Second, I will present a paper on the subject to the Annual Assembly of RTCA in November of this year.

Please be assured that I can and will respect the proprietary nature of specific company disclosures. The number of individuals and companies with whom I will hold these discussions will make "protective generalization" quite feasible.

APPENDIX 1 (contd.)

As a responsible industry it is my belief that we face some kind of a bottom line in terms of NASA support of our advanced technology requirements. Do we have needs as an industry that NASA is able to fulfill by virtue of its unique capabilities and facilities? Or should we tell NASA to take its modest resources elsewhere where this kind of catalyzing effort will be more productive?

I look forward to our meeting in the sincere hope that it can serve a useful purpose in assuring a constructive relationship between our industry and this unique Government Agency.

Very truly yours,

G. F. Quinby
Principal
G. F. Quinby Associates

APPENDIX 1 (contd.)

Letter Addressees

Charles B. Husick, Senior Vice President
Cessna Aircraft

C. A. Rembleske, Vice President-Engineering
Beech Aircraft

Paul Gralnick, Manager-General Aviation Avionics
Engineering - Bendix

Edward B. Moore, President
EDO-Aire Division, EDO Corporation

William L. Firestone, Vice President & General Mgr.
RCA Avionics

Robert T. Cox, President
King Radio

Donald J. Grommesh, Vice President-Research & Eng.
Gates Learjet

Dave Givens, Advanced Product Development
Sperry Avionics

APPENDIX 2

NASA LANGLEY RESEARCH CENTER
P.O. L-11593B

ASSESSMENT OF GENERAL AVIATION ADVANCED TECHNOLOGY UTILIZATION MEETING FORMAT

INTRODUCTIONS

BACKGROUND - RTAC/AAC Sub-Committee. RTCA SC-133 peripherals.
SAE A-4 EFI AS

FOREIGN COMPETITION - NASA must make reports available
FOA. (+ or -?)

STATEMENT OF WORK

DEFINITIONS AND SEMANTICS: Avionics, Controls, Human Factors

NASA mission now emphasizes aeronautics.

1. What is your company awareness and use of NASA avionics resources? Need better liasion? How?
2. Is General Aviation avionics advanced technology self-sufficient?
 - a. Technology forecast cycle
 - b. Risk limitations
 - c. Other
3. How should NASA Avionics Technology be applied to General Aviation?
 - a. System architecture
 - b. Simplified sensor development
 - c. Antenna technology exploration, pattern measurement
 - d. Display technology
 - e. Avionics controls; I-O concepts
 - f. Other? (Fibre optics, Fluidics)

APPENDIX 2 (contd.)

4. Your company use and future of CRT and other electronics displays.
5. Your company microprocessor application? Future trend? Data buss? Fly by wire?
6. Your company control/guidance design technique? Use of simulation?

APPENDIX 3

PARTICIPANTS IN INTERVIEWS

RCA Avionics Systems Division - Van Nuys, CA.

Larry Parsons, Vice President-Engineering
Ray Aires
George Lucchi

Sperry Avionics Division, Sperry Flight Systems - Phoenix, AZ.

Bill Robinson, Vice President-Engineering
Dave Givens
Jim Davis

Gates Learjet Corporation - Tucson, AZ.

Richard Lukso, Strategic Avionics Planning

Beech Aircraft Corporation - Wichita, KS.

Chet A. Rembleske, Vice President-Engineering
Leroy B. Clay, Manager-Advanced Design
Harold Swearingen

Bendix Avionics Division - Ft. Lauderdale, FL.

George W. Church, Vice President & General Manager
Lou Giuliano
Paul Gralnick, Director-GA Avionics Engineering

Cessna Aircraft Company - Wichita, KS.

Charles B. Husick, Senior Vice President

EDO-Aire Division - EDO Corporation - Fairfield, N.J.

Edward B. Moore, President
Gerald H. Hoffman, Vice President-Marketing

NARCO Avionics - Ft. Washington, PA.

Norman A. Messinger, Director Advanced Development
John W. Bail *

* Resigned from NARCO in 1979.

APPENDIX 3 (contd.)

King Radio - Olathe, KS.

Edward J. King, Jr., Chairman
Robert T. Cox, President
Gary Burrell, Vice President-Engineering

General Aviation Manufacturers Association - Washington, D.C.

Stanley J. Green, Vice President and General Counsel

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9. Performing Organization Name and Address G. F. Quinby Associates 520 Ft. Washington Ave. Ft. Washington, PA. 19034				10. Work Unit No.	
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				14. Sponsoring Agency Code	
15. Supplementary Notes Langley technical monitor: W. E. Howell Final Report					
16. Abstract <p>The author undertook an assessment of General Aviation's utilization of Advanced Avionics Technology. Needs of the General Aviation Industry for services and facilities which might be supplied by NASA were examined. In the data collection phase, twenty-one individuals from nine manufacturing companies in General Aviation were interviewed against a carefully prepared meeting format.</p> <p>The report credits General Aviation Avionics Manufacturers with a high degree of technology transfer from the forcing industries such as television, automotive, and computers and a demonstrated ability to apply advanced technology such as large scale integration and micro-processors to avionics functions in an innovative and cost effective manner. The industry's traditional resistance to any unnecessary regimentation or standardization was confirmed. Industry's self-sufficiency in applying advanced technology to avionics product development was amply demonstrated. NASA support was perceived by the industry to be unnecessary in major areas such as system architecture, microprocessor application, and multi-modal use of cathode ray tubes. NASA research capability could be supportive in areas of basic mechanics of turbulence in weather and alternative means for its sensing. Other areas that should be explored for NASA research assistance include improvements in aircraft antenna pattern management at L-Band and C-Band.</p>					
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